Appendix G

Contaminant Profile Data Sheets

CONTENTS

Appendix G

Contaminant Profile Data Sheets

This appendix presents profile data sheets for the contaminants that were among those present in the largest quantities. Profile data sheets appear separately for nonradiological contaminants and radiological contaminants.

The profile data sheets provide a quick reference summary for each of the principal contaminants. Each sheet very briefly lists typical physical and chemical forms and properties of the contaminant, common uses, general presence in the environment, toxicology, and the results of environmental monitoring at the Subsurface Disposal Area (SDA). For radiological contaminants, the radiological properties and radiotoxicity are included.

The caution concerning environmental monitoring results, stated in Section 6.3.6 and in Appendix F, is repeated here. Detection of contaminants in environmental media at the SDA does not always imply that the contaminants came from the SDA waste. Contaminants detected in monitoring could also have resulted, for example, from emissions at other facilities.

Profile Data Sheets for Some Nonradiological Contaminants of Interest

ASBESTOS

Synonyms: Various types: chrysotile, crocidolite, actinolite, amosite, anthophyllite, and tremolite.

Chemical Abstract Services (CAS) No.: 1332-21-4 (each type of asbestos also has its own CAS number)

Physical Form

Asbestos is comprised of fibers or filaments from naturally occurring mineral silicates. The fibrous structure of asbestos distinguishes it from other minerals.

Chemical Form

Asbestos is divided into two groups, of which there are six types. The distinction between the two groups is that in one, the minerals have a sheet or layered structure, and in the other, they have a chain-like crystal structure. Chrysotile is the most commonly used of the six types of asbestos.

Chemical and Physical Properties

Asbestos may be white, blue, brown, gray, green, or yellow in color. It is noncombustible and conducts heat and electricity poorly. These properties, along with strength, flexibility, brittleness, and color, vary depending on which type of asbestos is being used.

Common Uses

Asbestos has been used in fireproof fabrics, brake linings, gaskets, roofing compositions, electrical and thermal insulations, and paint filler and as a reinforcing agent in rubber, plastics, and cement. Chrysotile accounts for 95% of the asbestos found in buildings.

Asbestos was extensively used for many years in construction until the 1970s, when governmental regulations began restricting its use.

General Presence in the Environment

Asbestos is a naturally occurring mineral throughout the world, and it is extracted from the earth in the form of rock and then processed. It is ubiquitous in the human environment; virtually everyone has been slightly exposed to asbestos to some extent through its use in construction.

Toxicology Highlights

Asbestos is a known human carcinogen. However, to be a significant health concern, the airborne fibers must be inhaled. Acute exposure to asbestos dust can be irritating to the skin or eyes and can cause irritation internally when ingested or inhaled. Chronic effects of long-term exposure are a high incidence of lung, laryngeal, and gastrointestinal cancers. The risks of low-level, nonoccupational exposure have not been established.

Environmental Monitoring Results at the SDA

Asbestos has not been monitored in environmental media at the SDA.

BERYLLIUM

CAS No.: 7440-41-7

Physical Form

Beryllium is a grayish-white metal.

Chemical Form

Beryllium is processed from several different ores, such as beryllium silicate and bertrandite, by exposure to the acid salts of the metal. There are many compounds of beryllium, but it is also often used in the elemental form.

Chemical and Physical Properties

Beryllium is a hard, odorless, brittle metal that is soluble in most acids and alkalies. It is the only stable, light-weight metal that has a high melting point, and it has an especially high strength-to-weight ratio.

Common Uses

The primary use for beryllium is as a hardening agent in alloys, mainly copper and aluminum, and as an oxide in ceramics. It has been used increasingly in the atomic energy industry as a source of neutrons when bombarded with alpha particles and as a neutron moderator in nuclear reactors. Beryllium is also used in radio tube parts and aerospace structures.

General Presence in the Environment

Beryllium is present naturally in the earth's crust at 2 to 10 ppm and is found in ores such as beryl, beryllium silicate, and bertrandite throughout the world. Widespread use has not been made of beryllium, so it is not encountered frequently in the human environment.

Toxicology Highlights

Beryllium is a probable human carcinogen. The most serious health hazards relate to inhalation of dust, which occurs in industries where beryllium is processed or milled. Acute exposure may result in respiratory disorders, dermatitis, corneal burns, and nonhealing ulcerations. Chronic exposure may cause pulmonary disease or cancer, which may take many years to appear.

Environmental Monitoring Results at the SDA

Beryllium has been detected occasionally in environmental media at the SDA.

CADMIUM

CAS No.: 7440-43-9

Physical Form

Cadmium is a blue-white metal in the elemental state.

Chemical Form

Cadmium is a metal or a grayish-white powder. It is most commonly found in compounds of oxides, hydrates, and chlorides.

Chemical and Physical Properties

Cadmium tarnishes in moist air, has poor corrosive resistance, becomes brittle when heated, is soluble in acids, lowers the melting point of some alloys, and can react vigorously with oxidizing materials.

Common Uses

Cadmium is used in brazing alloys and solders, fire protection systems, batteries, power transmission wires, television phosphors, electroplating and machinery enamel, fungicides, and photography and for the control of atomic fission in nuclear reactors.

General Presence in the Environment

Cadmium does not occur naturally uncombined, and only one cadmium mineral (cadmium sulfate) exists. It is usually found in combination with lead, copper, or zinc ore. Its fumes can be found in the atmosphere in areas where it is processed industrially, in welding shops, and where scrap metals containing cadmium have been remelted. It can also be found in dump sites where products that contain cadmium have been disposed of.

Toxicology Highlights

Cadmium is a probable human carcinogen. The risk of cancer depends on the duration and level of exposure. Cadmium targets the kidneys, blood, prostate, and respiratory tract. Exposure to cadmium has cumulative effects, and its fumes are highly toxic when inhaled. Chronic exposure to cadmium may cause permanent damage to the lungs or nervous system.

Environmental Monitoring Results at the SDA

Cadmium has been detected rarely in environmental media at the SDA.

CARBON TETRACHLORIDE

Synonyms: Carbon chloride, perchloromethane, tetrachloromethane, and R-10 refrigerant.

CAS No.: 56-23-5

Physical Form

Carbon tetrachloride is a clear, colorless, heavy liquid.

Chemical Form

Carbon tetrachloride is an organic solvent classified as a halogen compound or chlorinated hydrocarbon.

Chemical and Physical Properties

Carbon tetrachloride has a characteristic sweetish odor and is stable under normal temperatures and pressures. Decomposition at high temperatures creates very toxic fumes of phosgene and corrosive and toxic fumes of chlorides and oxides.

Common Uses

Carbon tetrachloride has been used as a refrigerant, agricultural fumigant, active insecticide, and solvent and in the production of semiconductors. It has been very effective in suppressing the flammability of more flammable fumigants and was commonly found in fire extinguishers. At one time, it was also used as a common household spot remover and dry cleaning agent. Since carbon tetrachloride has been recognized as a carcinogen, its use has been sharply curtailed.

General Presence in the Environment

Carbon tetrachloride is manufactured by the reaction of chlorine with methane. Because this is a manufactured chemical having widespread use, it has been introduced into the environment through industry and its use as a consumer product.

Toxicology Highlights

Carbon tetrachloride is considered to be a probable human carcinogen. It is a skin and eye irritant. The liver is sensitive to exposure to carbon tetrachloride. Chronic exposure to high concentrations can result in depression of the central nervous system. Acute exposure can cause functional and destructive injury of the liver and kidneys or possibly cancer.

Environmental Monitoring Results at the SDA

Carbon tetrachloride is detected frequently in environmental media at the SDA.

LEAD

CAS No.: 7439-92-1

Physical Form

Lead is a silvery-gray solid metal in the elemental state.

Chemical Form

Lead is found mainly in mineral form and rarely in the elemental state. There are more than 70 lead compounds, both organic and inorganic. Lead also occurs in uranium and thorium minerals, arising from radioactive decay.

Chemical and Physical Properties

Lead is a heavy, dense, malleable, gray solid that resists corrosion and is relatively impenetrable to radiation. Lead is compatible with a variety of substances and has one of the widest ranges of application of any metal, except possibly iron. It dissolves in nitric and sulfuric acid.

Common Uses

The most common uses of lead are in the manufacture of storage batteries and in the production of gasoline additives (which is being phased out because of adverse health effects). Lead is used in paints, bullets, and solder and fusible alloys and in construction. It is also used as protective shielding against sources of radiation.

General Presence in the Environment

Lead exists widely throughout the world in a number of ores. It is found widely in the human environment by virtue of its use in paints and as a gasoline additive. The major portion of lead in air is in inorganic form.

Lead dust and fumes can be found in indoor firing ranges and smelting industries. Trace amounts of lead can be found in some drinking water and in food through its absorption by plants.

Toxicology Highlights

Lead fumes and lead compounds cause poisoning after prolonged exposure. Skin absorption is of significance only from organic lead compounds. Lead is a probable human carcinogen.

Early signs of lead poisoning are fatigue and sleep disturbances. Chronic exposure can cause anemia, cancer of the kidneys, nervous system damage, and reproductive defects.

Environmental Monitoring Results at the SDA

Lead has been detected rarely in environmental media at the SDA.

MERCURY AND ITS COMPOUNDS

CAS No.: 7439-97-6

Physical Form

Mercury is a silvery liquid with a metallic luster or mirror-like appearance.

Chemical Form

There are at least 68 inorganic and 42 organic derivatives of mercury. Mercuric sulfide is the chief source of elemental mercury. Other common forms are mercury sulfate, mercury nitrate, mercury chloride, phenyl mercury acetate, and mercury oxides.

Chemical and Physical Properties

Mercury is a metal that remains liquid throughout a broad range of temperatures. In its pure form, it is stable under normal conditions, odorless, insoluble in water, and extremely heavy. It is incompatible with many chemicals, such as strong oxidizing agents, and when in contact with them, can become explosive and emit highly toxic vapors.

Common Uses

Mercury is used in amalgams and electrical apparatus; in the production of chlorine and caustic soda, thermometers, batteries, and vapor pressure lamps; and as a coolant and gamma ray absorber in nuclear power plants. It is most recently being used as a catalyst in polyurethane foams.

General Presence in the Environment

Mercury ore is found in rocks of all classes, the most common being cinnabar. Naturally occurring vapor concentrations in the air vary widely around ore deposits and areas of volcanic activity. Mercury can be found in drinking water and in food sources in trace amounts. It is frequently encountered in the human environment from the disposal of scrap batteries and mercury-containing products and at mildew-resistant, mercury-containing paint and mercury treatment facilities where it is processed.

Toxicology Highlights

Mercury poisoning may damage the kidneys, brain, nerves, gastrointestinal system, and respiratory tract.

Environmental Monitoring Results at the SDA

Mercury has been detected rarely in environmental monitoring at the SDA; it has also been detected in direct sampling of the Acid Pit.

METHYLENE CHLORIDE

Synonyms: Methylene dichloride, dichloromethane, and methane dichloride.

CAS No.: 75-09-2

Physical Form

Methylene chloride is a colorless liquid.

Chemical Form

Methylene chloride is an organic solvent classified as a halogenated aliphatic compound.

Chemical and Physical Properties

Methylene chloride is a colorless, volatile liquid with a penetrating ether-like odor. It is soluble in alcohol and ether, slightly more soluble in water than other chlorinated solvents, nonflammable and nonexplosive in air, and can be broken down by heat to form an acid.

Common Uses

Methylene chloride is used as a blowing agent in foams and in plastic processing. As a solvent, it has many applications, including coating photographic films, aerosol formulations, extraction processes, and paint stripping. Because methylene chloride has a narcotic effect at high concentrations, it was once used as an anesthetic.

General Presence in the Environment

Methylene chloride is not known to occur naturally in the human environment; however, through its widespread use as a blowing agent for foams and as a solvent in industry and consumer products, it can be found as a contaminant in the atmosphere and soil and in areas where products containing methylene chloride have been disposed of.

Toxicology Highlights

Methylene chloride is a probable carcinogen. Symptoms of exposure may be dizziness, nausea, and irritation of the skin and eyes. Exposure may also damage the central nervous system.

Environmental Monitoring Results at the SDA

Methylene chloride has been detected rarely in environmental media at the SDA.

METHYL ISOBUTYL KETONE

Synonyms: 4-methyl-2-pentanone, isopropyl acetone, hexone, and MIBK.

CAS No.: 108-10-1

Physical Form

Methyl isobutyl ketone is a clear liquid.

Chemical Form

Methyl isobutyl ketone is an organic solvent classified as an aliphatic ketone.

Chemical and Physical Properties

Methyl isobutyl ketone is a colorless, stable liquid with a pleasant odor. It is slightly soluble in water, has a low boiling point, may react violently with oxidizers, and is flammable as a liquid or vapor. Its vapors are heavier than air and may travel a considerable distance.

Common Uses

Methyl isobutyl ketone is used as a solvent in gums and resins, paints, varnishes, and lacquers; in the manufacture of methylamyl alcohol; in extraction processes, including extraction of uranium from fission products; in organic synthesis; and as a denaturant for alcohol.

General Presence in the Environment

Methyl isobutyl ketone is not found naturally in the human environment; however, through its widespread use as a solvent in industry and consumer products, it has been introduced into the environment. It has been found as a contaminant in water and air in small quantities.

Toxicology Highlights

In both acute and chronic exposure, inhalation of methyl isobutyl ketone is the principal health hazard. It can affect the central nervous system and respiratory system.

Environmental Monitoring Results at the SDA

Methyl isobutyl ketone has not been detected in environmental media at the SDA.

1,1,1-TRICHLOROETHANE

Synonyms: Methyl chloroform, trichloromethylmethane, and alpha-trichloroethane.

CAS No.: 71-55-6

Physical Form

1,1,1-trichloroethane is a clear, colorless liquid.

Chemical Form

1,1,1-trichloroethane is an organic solvent classified as an aliphatic halogen compound.

Chemical and Physical Properties

1,1,1-trichloroethane has a mild, sweet odor and is chemically reactive to metals such as zinc and aluminum. It slowly decomposes over time, yielding hydrogen chloride, and is noncombustible as a liquid; however, its vapors are flammable.

Common Uses

1,1,1-trichloroethane is used almost exclusively as a solvent in cleaning, degreasing of metals, and textile processing. It has some use as a constituent in food packaging and a propellant in aerosols and is used in the manufacture of cosmetics.

General Presence in the Environment

1,1,1-trichloroethane is not known to occur naturally in the human environment; however, through widespread use as a solvent and in consumer products, it is generally present in the atmosphere at about 1 ppb.

Toxicology Highlights

1,1,1-trichloroethane is probably the least toxic of the chlorinated solvents. The principal response from acute or chronic exposure is depression of the central nervous system by inhalation of its vapors. It can also cause eye and skin irritation.

Environmental Monitoring Results at the SDA

1,1,1-trichloroethane is detected frequently in environmental media at the SDA.

TRICHLOROETHYLENE

Synonyms: Trichloroethene, acetylene trichloride, ethylene trichloride, and TCE.

CAS No.: 79-01-6

Physical Form

Trichloroethylene is a colorless liquid.

Chemical Form

Trichloroethylene is an organic solvent classified as an aliphatic halogen compound.

Chemical and Physical Properties

Trichlorethylene is a colorless liquid that has a sweet odor and is virtually insoluble in water. It is stable under normal temperatures and pressures, has a low boiling point, and is nonflammable.

Common Uses

Trichloroethylene is a common solvent used in industry for the degreasing of metals; the manufacture of organic chemicals and pharmaceuticals; dry-cleaning; in paints and varnishes, adhesives, and textile processing; and as a fumigant. Its continued use in foods, drugs, and cosmetics is prohibited.

General Presence in the Environment

Although trichloroethylene is not known to occur naturally, it is widely distributed in the human environment and has been detected in air, food, and water. It has been introduced to the environment by dry-cleaners, the food processing industry, and in landfills where it has been disposed of. It has been implicated as a possible factor in the depletion of the ozone layer.

Toxicology Highlights

The most significant source of exposure to trichloroethylene is from inhalation of its vapors and absorption through the gastrointestinal tract and skin. Inhalation can cause giddiness, headaches, and sleepiness. The target organs include the liver and central nervous system. Studies are underway as to its potential carcinogenicity.

Environmental Monitoring Results at the SDA

Trichloroethylene has been detected frequently in environmental media at the SDA.

1,1,2-TRICHLORO-1,2,2-TRIFLUOROETHANE

Synonyms: Freon 113, refrigerant 113, Freon TF solvent, and trichlorotrifluoroethane.

CAS No.: 76-13-1

Physical Form

1,1,2-trichloro-1,2,2,-trifluoroethane is a colorless liquid.

Chemical Form

1,1,2-trichloro-1,2,2-trifluoroethane is an organic compound classified as a chlorinated aliphatic halogen or nonhydrogenated fluorocarbon. It is one of many fluorine-containing compounds.

Chemical and Physical Properties

1,1,2-trichloro-1,2,2-trifluoroethane is a colorless, volatile liquid. It is slightly flammable and extremely persistent, but it is stable under normal temperatures and pressures. The chlorine atoms present in 1,1,2-trichloro-1,2,2,-trifluoroethane directly contribute to its hazardous properties and persistence in the atmosphere.

Common Uses

1,1,2-trichloro-1,2,2-trifluoroethane is available commercially, with the most common use being as a solvent for cleaning electronic equipment and degreasing machinery. It has also been used in fire extinguishers, solvent drying, dry-cleaning solvents, and as a blowing agent and refrigerant.

General Presence in the Environment

Although 1,1,2-trichloro-1,2,2-trifluoroethane does not occur naturally, it can be found in the environment, especially in the stratosphere, where it produces significant amounts of chlorine atoms and leads to the destruction of atmospheric ozone. 1,1,2-trichloro-1,2,2-trifluoroethane is released in the industrial setting through evaporation at room temperature, adherence to cleaned parts when removed, and accidental loss in the refrigeration manufacture industry.

Toxicology Highlights

The most likely exposure to 1,1,2-trichloro-1,2,2,-trifluoroethane is by inhalation of the vapors. In small quantities, it is fairly nontoxic; however, in both acute and chronic exposure, it may target the cardiovascular system. Contact with the skin or eyes can cause redness and irritation.

Environmental Monitoring Results at the SDA

1,1,2-trichloro-1,2,2-trifluoroethane has been detected frequently in environmental media at the SDA.

MISCELLANEOUS ACIDS

CAS No.: Not applicable

Physical Form

Acids can be a gas or liquid and can range from transparent to dark in color.

Chemical Form

All acids contain hydrogen and can be classified as organic or inorganic. Some of the major acids are sulfuric acid (H_2SO_4), nitric acid (HNO_3), and hydrogen fluoride (HF).

Chemical and Physical Properties

Acid solutions have one or more of the following properties: sour taste, ability to make litmus dye turn red and to cause other indicator dyes to change to characteristic colors, and ability to react with and dissolve certain metals and react with bases or alkalies. Hydrogen fluoride, nitric acid, and sulfuric acid are all strong irritants, corrosive, and considered to be fuming acids.

Common Uses

Sulfuric acid, nitric acid, and hydrogen fluoride are commonly used acids. All three are used as laboratory reagents, in steel or stainless-steel processing, and in the manufacture of fertilizers. Sulfuric acid is also used in batteries, electroplating baths, iron, rayon, and film. Nitric acid is used in pharmaceutical processing, metallurgy, ore flotation, urethane, rubber chemicals, and the reprocessing of spent nuclear fuel. Hydrogen fluoride is used in aluminum production, fluorocarbons, glass etching, and gasoline and uranium processing.

General Presence in the Environment

Sulfuric acid, nitric acid, and hydrogen fluoride are present in the human environment because of their widespread use. Detection occurs mainly in industrial and manufacturing areas where large quantities of acids are used for specific processes (e.g., nitrogen oxide and dioxide are byproducts of nitric acid, and sulfuric dioxide and trioxide are byproducts of sulfuric acid). These acids can be emitted through exhaust stacks, leaking pipes, or spills.

Toxicology Highlights

Inhalation of fumes emitted from the acids themselves or from the processes they are used in is the principle hazard for toxic exposures. Most acids are strong irritants and can cause digestive disorders, lung or kidney damage, and respiratory problems. In addition, hydrogen fluoride, sulfuric acid, and nitric acid can cause burns when inhaled or ingested or when in contact with the skin.

Environmental Monitoring Results at the SDA

Acids have not been monitored at the SDA.

Profile Data Sheets for Some Radiological Contaminants of Interest

AMERICIUM-241

CAS No.: 14596-10-2

Physical Form

Americium is a silver-white crystalline solid.

Chemical Form

Americium (Am)-241 can be found in compounds with oxygen, halogens, or lithium.

Chemical and Physical Properties

Americium is stable under normal pressures and temperatures and is soluble in dilute acids. It is not a fire hazard in solid form; however, it is a dangerous fire hazard as a dust, powder, or fume.

Radiological Properties

Plutonium-241 yields Am-241 upon beta decay. Americium is mainly an alpha-emitter, with some gamma or x-ray radiation. It has a half-life of about 433 years.

Common Uses

Americium-241 is used in gamma radiography and radiochemical research, as a diagnostic aid in bone mineral analysis, and in electronic devices such as smoke detectors.

General Presence in the Environment

Americium is not found naturally in the environment, but it exists as fallout from nuclear weapons testing.

Radiotoxicology Highlights

Americium-241 emits alpha radiation during radioactive decay. Intact skin is an effective barrier for alpha radiation; therefore, the effects of americium are observed after it has been ingested or inhaled. After inhalation, Am-241 resides principally in the lungs.

Environmental Monitoring Results at the SDA

Americium-241 is detected frequently in environmental media at the SDA.

CARBON-14

CAS No.: None

Physical Form

Carbon is most commonly seen as a black elemental solid, but it is also found as diamonds, an oxidized gas (CO and CO_2), or trapped in a metallic matrix or on the surface of nonmetallic substances.

Chemical Form

Carbon is found in all organic compounds.

Chemical and Physical Properties

Carbon, especially when finely divided, readily oxidizes to CO and CO_2.

Radiological Properties

Carbon (C)-14 is a low-energy beta emitter from natural sources and from nuclear activities. No gamma rays result from C-14 decay. It has a half-life of 5,730 years.

Common Uses

The natural presence of C-14 in the environment is used by scientists to age-date archeological artifacts containing carbon. It is also used as a radiation source in thickness gauges and as a tracer in organic chemistry procedures.

General Presence in the Environment

Carbon-14 occurs naturally in the environment because of the action of cosmic radiation in the upper atmosphere. In addition, the atmospheric testing of nuclear weapons and the nuclear fuel cycle have added to the worldwide inventory of C-14. Very small amounts of C-14 are found in all living things.

Radiotoxicology Highlights

Because of its low beta energy and the absence of gamma radiation, C-14 is principally an internal hazard. It is readily absorbed into biological systems and tissue. Carbon-14 may preferentially concentrate in one or more parts of the body depending on the nature of the chemical compound into which it has been incorporated, but in general it deposits throughout all parts of the body.

Environmental Monitoring Results at the SDA

Because C-14 is ubiquitous in the environment, no effort has been made to monitor C-14 at the SDA.

CESIUM-137

CAS No.: 10045-97-3

Physical Form

Cesium can be a silvery liquid or a soft solid formed of silver-white hexagonal crystals.

Chemical Form

In nature, cesium is found only in minerals, never in the elemental state. There are many compounds of cesium, the most common being the oxides.

Chemical and Physical Properties

Cesium is an alkali metal that reacts violently with many substances, including water. It has an extremely low melting point, is very sensitive to light, ignites easily, and must be stored in mineral oil or kerosene.

Radiological Properties

Cesium (Cs)-137 is an artificial radionuclide generated through nuclear fission of uranium. It is a beta- and gamma-emitter, with a half-life of about 30 years.

Common Uses

Cesium can serve as a catalyst in the manufacture of synthetic resins and is used in photoelectric cells and as the heat transfer fluid in power generators. Cesium-137 has been approved for sterilization of certain foodstuffs.

General Presence in the Environment

Cesium is found at approximately 2 ppb in seawater and in detectable amounts in plants, animals, humans, mineral waters, soils, and the atmosphere. Cesium-137 is found in the environment as a result of fallout from nuclear weapons testing.

Radiotoxicology Highlights

Prolonged or repeated exposure to Cs-137 by inhalation, ingestion, or skin contact may result in cancers of the thyroid, skin, and bone. Cesium can act as an analog of potassium, which increases its ability to be distributed throughout the body, thereby giving essentially a whole-body dose.

Environmental Monitoring Results at the SDA

Cesium-137 is detected frequently in environmental media at the SDA.

COBALT-60

CAS No.: 10198-40-0

Physical Form

Cobalt is a silver-gray metal and can be formed into pellets or wire needles.

Chemical Form

Cobalt (Co)-60 is available as cobaltous chloride, solid cobaltic oxides, and other compounds.

Chemical and Physical Properties

Cobalt is a steel-gray, shiny, hard, somewhat malleable metal. It is insoluble in water, stable under normal temperatures and pressures, noncombustible except as a powder, and corrodes readily in air.

Radiological Properties

Cobalt-60 is an activation product of the naturally occurring Co-59, when Co-59, as a constituent of alloys, undergoes nuclear irradiation in nuclear reactors. It has a half-life of about 5 years, emitting intense beta and gamma radiation.

Common Uses

Cobalt-60 is one of the most common radioisotopes used in industry and research. It has replaced iridium in cancer and medical research and in the inspection of materials to reveal internal structure or flaws. It has been approved for gamma irradiation of certain foodstuffs.

General Presence in the Environment

Cobalt is found throughout nature, but it is relatively rare. Cobalt-60 is manufactured and is found in the environment as a result of fallout from weapons testing.

Radiotoxicology Highlights

Cobalt-60 emits both beta and gamma radiation; high levels of exposure can be lethal. Cobalt accumulates in numerous organs of the body.

Environmental Monitoring Results at the SDA

Cobalt-60 is detected frequently in environmental media at the SDA.

PLUTONIUM-239 AND PLUTONIUM-240

CAS No.: 7440-07-5

Physical Form

Plutonium is a silver-white crystalline solid.

Chemical Form

Plutonium can be made into many compounds, including oxides, fluorides, hydrides, and nitrates.

Chemical and Physical Properties

Plutonium metal is highly reactive, insoluble in water, and oxidizes rapidly.

Radiological Properties

Plutonium is a manufactured radioactive heavy element, and some of its radionuclides are fissile. Both plutonium (Pu)-239 and Pu-240 are produced by neutron capture in uranium (U)-238, and Pu-239 is also a product from neptunium (Np)-239. Alpha spectrometry cannot distinguish between Pu-239 and Pu-240; therefore, these radionuclides are usually discussed together.

Plutonium is one of the most radiotoxic of the elements. Plutonium-239 and Pu-240 emit alpha particles with approximately the same amount of decay energy being released; however, their half-lives are different. Plutonium-239 has a half-life of about 24,000 years; Pu-240 has a half-life of about 6,600 years.

Common Uses

Plutonium has been used in nuclear weapons, in some reactor fuels, and in remote power-generation applications (e.g., space applications).

General Presence in the Environment

Because plutonium is a manufactured element, it is not found naturally in the environment. It has been released into the atmosphere through nuclear explosions. The minute quantities found in the soil bind tightly, so there is little plant uptake.

Radiotoxicology Highlights

Plutonium-239 and Pu-240 emit alpha radiation during radioactive decay. Intact skin is an effective barrier for alpha radiation; therefore, the effects of plutonium are observed after it has been ingested or inhaled. After inhalation, plutonium may remain in the lungs, but it can move to the bones and liver. It generally stays in the body for a very long time and continues to expose the surrounding tissues to radiation. Inhalation can cause lung tumors. If the dose is sufficient, radiation sickness, lung cancer, anemia, or bone cancer may occur.

Environmental Monitoring Results at the SDA

Plutonium-239/Pu-240 is detected frequently in environmental media at the SDA.

PLUTONIUM-241

CAS No.: 7440-07-5

Physical Form

Plutonium is a silver-white crystalline solid.

Chemical Form

See profile sheet on plutonium (Pu)-239 and Pu-240.

Chemical and Physical Properties

See profile sheet on Pu-239 and Pu-240.

Radiological Properties

Plutonium is one of the most radiotoxic of the elements. Plutonium-241 decays by emitting beta particles and has a half-life of about 14 years. Its decay produces Am-241.

Common Uses

See the profile sheet on Pu-239 and Pu-240.

General Presence in the Environment

See the profile sheet on Pu-239 and Pu-240.

Radiotoxicology Highlights

The beta radiation from Pu-241 can affect the skin and eyes and injure the body in general, especially if the Pu-241 is inhaled. Although Pu-241 is very toxic, it requires a larger exposure than Pu-239 or Pu-240 to produce damage. Acute or chronic exposure to beta radiation is dependent upon the dose and length of the exposure. If exposure is sufficient, radiation sickness and possible permanent bone, lung, or liver damage may occur.

Environmental Monitoring Results at the SDA

Plutonium-241 has not been monitored at the SDA because it is of a lower radiotoxicity than Pu-238 and Pu-239/240 and is more difficult to measure.

STRONTIUM-90

CAS No.: 7440-24-6 [strontium, CAS number not available for strontium (Sr)-90]

Physical Form

Strontium is a silver-white to pale yellow metal.

Chemical Form

Strontium-90 is available in mixtures of yttrium (Y)-90 and strontium (Sr)-89 chlorides; it can also be made into compounds of carbonates and sulfates.

Chemical and Physical Properties

Strontium-90 is produced in the fission of U-235 and is chemically similar to calcium. It rapidly becomes yellow on exposure to air and ignites easily when exposed to oxygen, forming hydrogen gas. It may react dangerously with oxidizers, acids, or water and when heated, may release toxic gases.

Radiological Properties

Strontium-90 decays into Y-90, which decays to zirconium (Zr)-90. It has a half-life of about 29 years and emits beta radiation with no accompanying gamma radiation.

Common Uses

Strontium-90 is used as a radiation source in industrial thickness gauges, to eliminate static charges, to provide ionizing radiation in luminous paint, and as a nuclear heat source.

General Presence in the Environment

In nature, strontium metal is found in ores throughout the world. It is ubiquitous in the atmosphere in relatively high concentrations and is, therefore, present in all living things. Strontium-90 is present from nuclear weapons tests, producing population exposure mainly through consumption of milk and dairy products, and in the air, water, and soil.

Radiotoxicology Highlights

The effects of acute or chronic exposure to beta radiation from Sr-90 depends upon the dose and length of exposure. Because it is so close to calcium in chemistry and metabolism, it is mainly deposited in areas where new bone cells are being formed. This can cause deformities or paralysis. If exposure is sufficient, radiation sickness or disorders of the lungs, heart, liver, or kidneys may occur.

Environmental Monitoring Results at the SDA

Strontium-90 is detected frequently in environmental media at the SDA.

TRITIUM

CAS No.: 10028-17-8

Physical Form

Tritium [hydrogen (H)-3] is a colorless gas.

Chemical Form

Tritium is one of the three naturally occurring isotopes of hydrogen. It may combine with oxygen to form tritiated water. It may also bond to metals as a hydride.

Chemical and Physical Properties

Tritium is an extra heavy hydrogen and is a product of fission. It is slightly soluble in water and stable under normal temperatures and pressures. It reacts strongly to oxidizers and is an explosive and fire hazard.

Radiological Properties

Tritium has a half-life of about 12 years and is a beta-emitter of very low energy.

Common Uses

Tritium is used in fusion-based thermonuclear weapons (hydrogen bombs), in watch dials and runway lights, in fusion energy research, and as a radioactive tracer in chemical, biochemical, and biological research.

General Presence in the Environment

Tritium is formed naturally from cosmic-ray interactions with the atmosphere. However, the greatest accumulation is from weapons testing. From all sources, it is disseminated in the environment as water and enters the hydrological cycle.

Radiotoxicology Highlights

Tritium enters the body by inhalation of the vapor and by absorption through the skin. Because it mixes with the body water, it does not selectively concentrate in any organ but is distributed uniformly. It leaves the body rapidly with a biological half-life of approximately 10 days. (The biological half-life is the time for a contaminant quantity in the body to be reduced by a factor of two because of biological elimination of the contaminant.) Acute and chronic exposure can cause irritation of the skin, eyes, and respiratory system and can possibly cause permanent damage. If exposure is sufficient, radiation sickness and possibly cancer or damage to the organs that tritium comes in contact with may occur.

Environmental Monitoring Results at the SDA

Tritium is detected frequently in environmental media at the SDA (see caution in the introduction to this appendix).

URANIUM-238

CAS No.: 7440-61-1

Physical Form

Uranium is a grayish-white solid.

Chemical Form

Uranium-238 is a naturally occurring radioactive isotope of uranium (U). Uranium-238 constitutes more than 99% of natural uranium, whereas U-235 constitutes less than 1%. Uranium is used in many compounds (e.g., as a nitrate, chloride, phosphate, fluoride, or sulfate).

Chemical and Physical Properties

Uranium is a dense solid that is strongly electropositive, reactive, ductile, and malleable.

Radiological Properties

Uranium-238 is fissionable and may be activated to produce Pu-239 in a reactor. Uranium-238 has a half-life of about 4.5 billion years. It decays mainly by alpha emission followed by some beta and gamma emission.

Common Uses

The most important use of U-238 is in nuclear energy applications, such as its use as nuclear fuel in breeder reactors. (U-235 is used to enrich natural uranium in nuclear fuel and was the energy source in the original atom bomb.) Compounds of uranium have been used to extend the life of incandescent lamps and have been used in photography and in making special steels. Uranium carbide is a good catalyst for the production of synthetic ammonia.

General Presence in the Environment

Uranium-238 is present naturally in the environment. Uranium is distributed abundantly in the soil and rocks and is also found in fertilizers, which explains its presence in food and human tissues at very low concentrations.

Toxicological Highlights

Uranium produces adverse health effects from both radioactive decay and from the element itself (e.g., chemical toxicity). Adverse health effects from both of these aspects are discussed in the following paragraphs.

Radiotoxicity

Uranium-238 emits alpha radiation during radioactive decay. Intact skin is an effective barrier for alpha radiation; therefore, the main routes of entry into the body are inhalation and ingestion. The target organs are the respiratory system, blood, liver, lymphatic system, kidneys, skin, and bone marrow. Cancer of the lung, bone, and lymphatic tissues has been reported for soluble compounds, whereas cancer of the lymphatic and blood-forming tissues has been reported for insoluble compounds.

Chemical Toxicity

Typically, the water soluble forms of uranium are more toxic than the insoluble forms. Following ingestion, the uranyl ion is rapidly absorbed from the gastrointestinal tract. Approximately 60% of the uranium ingested is excreted in 24 hours and 25% may be fixed to the bone. The uranyl ion can cause acute renal damage and failure, which may be fatal. However, if exposure is not severe, the tissue may be able to regenerate itself.

Environmental Monitoring Results at the SDA

Uranium-238 is detected rarely in environmental media at the SDA.

BIBLIOGRAPHY

Amdur, M. O., J. Doull, C. D. Klaassen, *Casarett and Doull's Toxicology, The Basic Science of Poison*, fourth edition, Pergamon Press, 1991.

Biological Effects of Ionizing Radiations IV, "Health Effects of Radon and Other Internally Deposited Alpha-Emitters," National Research Council, National Academy Press, Washington D.C, 1990.

Biological Effects of Ionizing Radiations V, "Health Effects of Exposures to Low Levels of Ionizing Radiation," National Research Council, National Academy Press, Washington D.C, 1990.

Clayton, George D. and Florence E. Clayton, *Patty's Industrial Hygiene and Toxicology*, third edition, Volume 1: General Principles, 1978.

Clayton, George D. and Florence E. Clayton, *Patty's Industrial Hygiene and Toxicology*, third edition, Volumes 2A and 2B: Toxicology, 1978.

Eisenbud, Merril, *Environmental Radioactivity, From Natural, Industrial, and Military Sources*, third edition, 1989.

Faust, L. G., *Health Physics Manual of Good Practices for Plutonium Facilities,* DOE/PNL-6534, UC-41, May 1988.

Fawell, J. K. and S. Hunt, *Environmental Toxicology: Organic Pollutants*, 1988.

Hall, E. J., *Radiobiology for the Radiobiologist*, second edition, Harper & Row Publishers, 1978.

Holtzclaw, Henry F., *General Chemistry*, eighth edition, 1988.

Integrated Risk Information System (IRIS), on-line computer database, U.S. Environmental Protection Agency, 1994.

Keyes, Paula, *Model EPA Curriculum for Training Building Inspectors, for Accreditation Under TSCA Section 206*, 1991.

Occupational Health Services Material Safety Data Sheets on CD ROM, Occupational Health Services, 1993.

Plog, Barbara, A., *Fundamentals of Industrial Hygiene*, third edition, 1988.

Sax, Irving N., *Dangerous Properties of Industrial Materials*, sixth edition, 1984.

Sax, Irving N. and Richard J. Lewis, Jr., *Hawley's Condensed Chemical Dictionary*, 11th edition, 1987.

Saxena, Jitendra, *Hazard Assessment of Chemicals, Current Developments*, Volume 3, 1987.

Shapiro, Jacob, *Radiation Protection, A Guide for Scientists and Physicians*, second edition, 1981.

Sittig, M., *Handbook of Toxic and Hazardous Chemicals and Carcinogens*, second edition, Noyes Publications, Park Ridge, New Jersey, 1985.

Toxicological Profile for Uranium, PB91-180471, Agency for Toxic Substances and Disease Registry, December 1990.

Toxicological Profile for Plutonium, PB91-180471, Agency for Toxic Substances and Disease Registry, December 1990.

Windholz, Martha, *The Merck Index, An Encyclopedia of Chemicals, Drugs, and Biologicals*, tenth edition, 1983.